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The Precambrian Basement of Illinois

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ABSTRACT

Sixteen borings in Illinois have penetrated and sampled the Precambrian basement rocks. The samples have been studied by optical methods, and the rocks have been identified as 11 granites, 4 granodiorites (2 of which occur in the same wells with granites), 1 rhyolite, 1 rhyolite porphyry, and 1 granophyre. The petrography of the rocks, the configuration and weathering of the Precambrian surface, and the relation of Illinois basement rocks to those of other midwestern states are discussed.

INTRODUCTION

The Precambrian basement of Illinois is covered by 2,000 to more than 13,000 feet of sedimentary strata. Drilling for oil or water seldom penetrates beneath the sedimentary cover, and samples of the basement rock only rarely become available for study. Consequently, much interest is attached to those borings that do penetrate into the Precambrian.

Grogan (1950) described the basement rocks from the six wells (table 1, wells 1-6) that had been drilled up to that time. Since then, ten more wells have encountered the Precambrian (table 1, wells 7-16), and this paper adds to and expands upon Grogan's information. In addition, data from three wells along the Mississippi River in Iowa (table 1) are included because of their close proximity to Illinois.

THE PRECAMBRIAN SURFACE

The contour map of the top of the Precambrian (fig. 1) is based on the structure of the top of the Galena (Trenton) shown on the Tectonic Map of the United States (Cohee et al., 1962). Combining this structure map with isopach maps of the units between the top of the Galena and the top of the basement rocks gave the contours on the top of the Precambrian. This method of preparing the map shows the basement shallower and smoother than it actually is in areas away from the relatively few control wells.

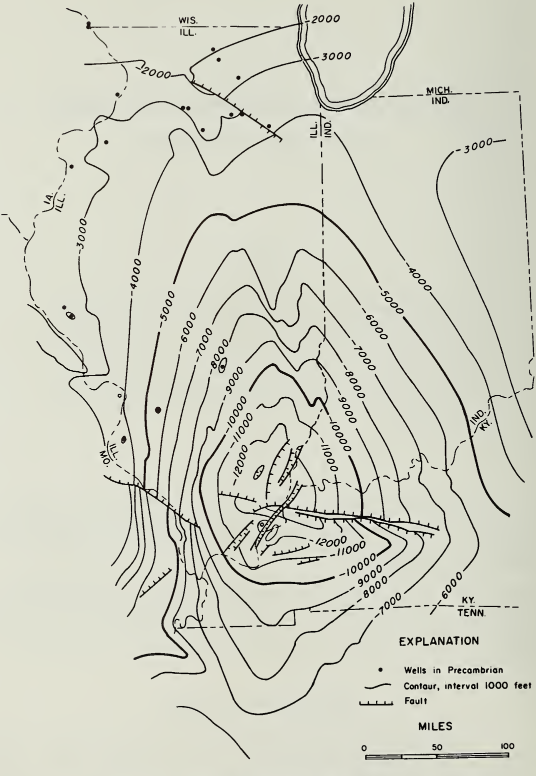

Figure 1 - Contour map of Precambrian surface (after Bell et al., 1964, figure 11).

The surface of the Precambrian is generally parallel to the top of the Galena. Important modifying factors are the thickness of the Mt. Simon Sandstone at the base of the Illinois Paleozoic and the relief on the Precambrian surface. The Mt. Simon Sandstone is relatively thick in central northern Illinois where it makes up about half of the sedimentary column, but its thickness is uncertain away from the sparse control points. A study of seismic reflecting horizons in southwestern Indiana gave depths to the Precambrian somewhat greater than those given in figure 1.

Local relief of about 800 feet on the Precambrian surface is shown by comparison of two granite tests eight miles apart in western Illinois (wells 4 and 5, fig. 2). Well 4, with 444 feet of Mt. Simon and 440 feet of Eau Claire, encountered the basement at 2,488 feet below sea level. Well 5, with no Mt. Simon and only 74 feet of Eau Claire, encountered the basement over 1,000 feet higher, at 1,409 feet below sea level. The Mt. Simon Sandstone is also absent in well 7 and is abnormally thin in well 12. The rugged topography of the top of the Precambrian is revealed by outcrops in the St. Francois Mountains of Missouri. Relief away from these localities is, of course, uncertain, but buried Precambrian hills probably underlie some of the structural highs in the younger strata.

The Precambrian rocks in Illinois apparently do not have a zone of deep weathering. In well 13, the top 71 feet of the rhyolite porphyry contains phenocrysts with a somewhat waxy luster. This may be an indication of weathering. The other wells encounter fresh looking igneous rock. The feldspar grains in the arkose that commonly overlies the Precambrian also have a fresh appearance. If a peneplain was developed on the basement rocks in Illinois, the weathered material was removed before deposition of the Paleozoic sediments.

Uncertainty about the Precambrian surface results not only from the paucity of data, especially for the deeper part of the Illinois Basin, but also because many of the tests were drilled on structural highs and, therefore, do not provide a random sampling. Wells drilled on structural highs are more likely to encounter buried Precambrian hills with more resistant rock types and with less weathering than typical for the Precambrian surface.

PETROGRAPHY OF THE BASEMENT ROCKS

General

The basement rocks encountered in borings in and immediately adjacent to Illinois are of granitic or closely related composition. The map (fig. 2) shows that granite, encountered in 11 of the 16 Illinois wells and in the 3 Iowa wells, is by far the most common rock type. Granodiorite, the next most abundant, was encountered in 4 wells, all in the northern part of the state. However, in 2 of these wells, Seele No. 1 in Winnebago County and Miller No. 1 in LaSalle County, the granodiorite was reached only after the drill had penetrated 434 and 155 feet of granite, respectively. Rhyolite and granophyre were encountered in 3 wells in south-central and western Illinois.

Scope and Methods of Study

All of the samples from 16 wells known to penetrate Precambrian rocks in Illinois and from 1 well just across the Mississippi River at Clinton, Iowa (table 1, well I-1), were examined petrographically. Samples from the six wells described

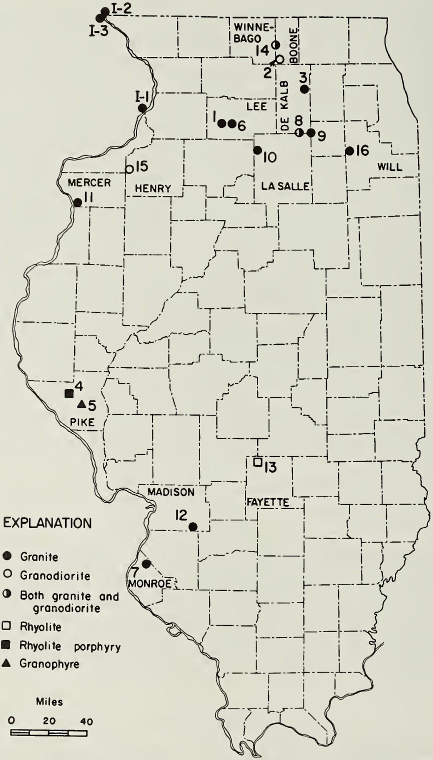

Figure 2 - Wells in Illinois that have penetrated the Precambrian basement. Numbers on map correspond to well numbers in Table 1.

by Grogan (1950) were included. However, the felsite in the Vedovell well, which Grogan thoroughly investigated and described, was not re-examined. The two additional Iowa occurrences, on which data were furnished by the Iowa Geological Survey, are listed in tables 1 and 2 and are shown on the map (fig. 2).

Optical methods of mineral identification and modal analysis were used. For five of the wells, core samples were available (tables 1, 2). These were studied in thin sections, and modal analyses were made by point count. Only drill cuttings were available for the remainder of the wells, and these were examined by binocular microscope and, in the crushed state, in oil immersion under the petrographic microscope. Thin sections were made from cuttings where it seemed desirable, particularly for mineral identification and examination of the textures of the fine-grained rocks. Modal analyses of drill cuttings of the coarse-grained rocks were made by visual estimate on representative samples of crushed cuttings in oil immersion. Differentiation between potash feldspar and soda-lime feldspar in the crushed cuttings was most readily made in oil of refractive index 1.528. Modal analyses of fine-grained rocks were made by visual estimate on thin sections of the cuttings.

Following Johannsen's (1932) classification, the division between granite and granodiorite is defined as the 50-50 point between potash feldspar and soda-lime feldspar. Although a more refined grouping of the rocks in table 2 could have been achieved by the addition of the intermediate subdivision (quartz monzonite), the uncertainty of mineral estimates on samples of drill cuttings is such that the simpler classification is more realistic.

Granites

The granites examined (11 in Illinois and 1 at Clinton, Iowa) are of the red variety, with the exception of the one in Mercer County, Fullerton No. 1 (table 1, well 11), which is pinkish gray. Mineralogically, all but the Will County sample (table 1, well 16; table 2, entry 11) appear to be normal granite with potash feldspar (including perthite) and quartz as the chief constituents. Plagioclase is present in varying amounts as sodic oligoclase, and biotite, accompanied in some samples by sparse hornblende, is the chief dark mineral. The Will County granite is of the alkalic variety and contains soda-amphibole (riebeckite) rather than biotite and hornblende as the ferromagnesian component.

In thin sections of the three drill core specimens 29 to 35 percent of quartz is present. Approximately the same amount occurs in the rocks for which there are only drill cuttings (table 2). The habit of the quartz is typical for granites and is characterized by clear, glassy, anhedral grains showing strain shadows under crossed nicols.

The potash feldspar is microcline and perthitic microcline in nine of the twelve granites, although in one of the nine, Seele No. 1 in Winnebago County (table 2, entry 7), perthitic orthoclase becomes predominant in the deeper samples. Microcline persists in the deeper samples, but whether it actually coexists with the orthoclase or is a contaminant from higher in the hole cannot be determined. In the other three granites, the potash feldspar is orthoclase in the Miller No. 1 well in LaSalle County (table 2, entry 5) and perthite in the two wells in southwestern Illinois in Madison and Monroe Counties (table 2, entries 1 and 3). The perthite in the Monroe County well (Theobald A-15) is typical exsolution perthite, consisting of a fine intergrowth of orthoclase and albite in string- and rod-shaped patterns. However, many perthite grains show later addition of clear, inclusion-free albite in patches and veins. In the Madison County well (Kircheis S-1), on the other hand, perthite grains are composed of intergrowths of relatively coarse, irregular patches of cloudy orthoclase and clear albite, and they apparently originated through replacement of orthoclase by albite. In some instances, albite has replaced over 50 percent of the original orthoclase grain, resulting in "antiperthite," which consists of patches of orthoclase in a grain composed mostly of albite. Some of the dusty inclusions in the orthoclase extend into adjacent patches of albite as residual rows and streaks. These inclusions retain the orientation inherited from the original orthoclase, and thus further indicate the replacement origin of the albite.

Plagioclase constitutes only a small percent of most of the granites, though it accounts for 26 percent of the Mercer County gray granite (Fullerton No. 1, table 2, entry 2). No plagioclase was found in the Will County alkaline granite (table 2, entry 11). Optical data on the plagioclase from six of the granites indicate sodic oligoclase (An10). In the other five granites the plagioclase was so clouded with inclusions that exact measurements of extinction angles could not be made. Index of refraction measurements indicated that the plagioclase in these five was oligoclase containing less than 20 percent of the anorthite molecule.

Ferromagnesian minerals are present in generally small amounts (less than 5 percent in most of the granites studied) but become slightly more abundant in Miller No. 1 in LaSalle County (table 2, entry 5), McElroy No. 1 in Lee County (table 2, entry 9), and McCoy No. 1 in Will County (table 2, entry 11). These minerals compose between 5 and 10 percent of the rock in the three samples. Dark brown or green biotite, more or less altered to chlorite, was the only ferromagnesian mineral observed in most of the samples. Dark green hornblende is present sparsely in four of the wells (table 2). As stated previously, riebeckite is the ferromagnesian component of the Will County granite. Chlorite is present in most of the rocks as an alteration product of biotite, hornblende, and riebeckite.

Among the accessory minerals, apatite and zircon are present in all the granites, and sphene, fluorite, epidote, and allanite occur in many. Carbonate is present to some degree in most of the granites and is probably secondary.

Texturally, the granites are medium to coarse grained. Most appear to be somewhat porphyritic in that the alkali feldspars, microcline and perthite, tend to form larger crystals than those of the other mineral components. In the most strikingly porphyritic rock, that from Theobald A-15 in Monroe County, large perthite phenocrysts contain zonally arranged quartz inclusions as a ring of small grains near the periphery of the phenocryst. Vague gneissic banding, caused by a partial segregation of the mineral components, is displayed by the Mercer County gray granite, Fullerton No. 1. Bands consisting almost wholly of microcline perthite lie between those composed of a mixture of microcline perthite, quartz, and oligoclase, with minor biotite and accessory minerals. Some of the quartz shows a tendency to occur in elongated aggregates of grains.

Granodiorite

Granodiorite was encountered in four wells (table 2): South No. 1 in Henry County, Taylor No. 1 in Boone County, Miller No. 1 (lower part) in LaSalle County, and Seele No. 1 (lower part) in Winnebago County. All four granodiorites are medium grained, somewhat porphyritic, and pink or gray. They contain less quartz and more dark minerals than the granites.

The alkali feldspars are generally the same as in the granites (table 2); they show the same tendency to form larger grains than the other mineral components.

The plagioclase in the granodiorites is zoned and has cores as calcic as An50 and rims in the range An15-20. The plagioclase compositions shown in table 2 are averages of the anorthite contents of the core and rim zones. No plagioclase composition is shown for Seele No. 1 because clouding of the plagioclase by inclusions prevented precise optical measurements.

The ferromagnesian minerals are more abundant in the granodiorites than in the granites (table 2). Dark brown biotite is the chief mineral, but dark green hornblende is conspicuous in all four granodiorites. Apatite, zircon, and sphene are present as accessories.

Rhyolites

The basement rock in the Fayette County boring, Weaber-Horn Unit No. 1, is a rhyolite (table 2, entry 17). Binocular examination of the drill cuttings (generally 3 mm. or less in diameter) showed the rock to be a red porphyry with phenocrysts of glassy quartz and red feldspar in a red aphanitic groundmass. Thin sections of several of the chips showed that the feldspar phenocrysts are perthitic orthoclase. The very fine-grained groundmass is holocrystalline, in part micrographic, and consists of quartz and orthoclase with a grain size of .005-.01 mm. (fig. 3a, b). Flow banding is demonstrated by quartz-rich and quartz-poor bands and by streaks of hematite dust (fig. 3a). Accessories, minor in amount, include apatite, zircon, and chlorite.

A similar rock was encountered in one of the two Pike County wells, Campbell No. 1 (table 2, entry 16). Like the Fayette County rock, the Campbell rhyolite is a reddish porphyry with phenocrysts of quartz and feldspar in an aphanitic groundmass. In thin sections, however, the groundmass of the Pike County rock, although still very fine grained (.01-.05 mm.), is a sharply defined mosaic of anhedral quartz and orthoclase crystals. Its texture is best described as aplitic (fig. 3c). This is in contrast to the relatively poor definition of the components in the groundmass of the Fayette County rhyolite and suggests that the two rocks have a different history of development. Although the aplitic texture could result from recrystallization of an extrusive rhyolite (Grogan, 1950), the texture may be essentially primary, developed during crystallization of a near-surface intrusive. As there is no direct evidence of recrystallization, it is concluded that the Pike County (Campbell) rhyolite represents a dike or other relatively small near-surface intrusive. The rock was termed rhyolite porphyry by Grogan (1950), and this name is retained to indicate a rock of somewhat coarser grain size than that of the typical extrusive rhyolite.

Granophyre

The second Pike County well, Mumford No. 1-21 (table 2, entry 18), encountered a rock of granitic composition that appears to have a texture intermediate between the granites and the rhyolite and rhyolite porphyry. Only drill cuttings (fragments generally 2 mm. or less in diameter) were available, and as grain size varied greatly, the overall texture of the rock could not be determined with complete satisfaction. From thin sections of several chips, however, it appeared that the rock is composed of phenocrysts of microcline and quartz in a groundmass consisting of micropegmatite, an uneven grained micrographic intergrowth of quartz and microcline (fig. 3d). Many of the quartz phenocrysts are euhedral, but most of the microcline phenocrysts are embayed by the micropegmatite. Because of the abundance of micropegmatite, Grogan (1950) called the rock a granophyre.

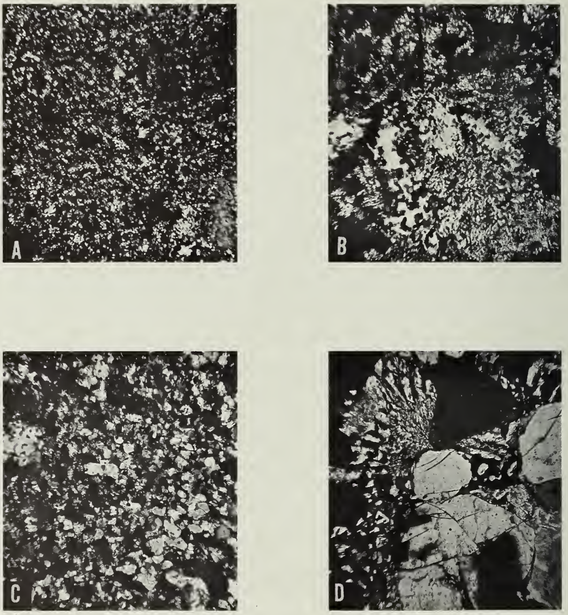

Figure 3 - Photomicrographs of thin sections of some Illinois Precambrian rocks.

(a) Rhyolite, Weaber-Horn No. 1, Fayette County, showing aphanitic groundmass. Narrow light-colored streaks are quartz-rich bands representing flow-banding. Crossed nicols. X65.

(b) Rhyolite, Weaber-Horn No. 1, Fayette County, showing micrographic texture in groundmass. Crossed nicols. X65.

(c) Rhyolite porphyry, Campbell No. 1, Pike County, showing aplitic texture of groundmass. Crossed nicols. X65.

(d) Granophyre, Mumford No. 1, Pike County; phenocrysts of quartz and feldspar in micrographic groundmass. Crossed nicols. X35.

RELATIONS OF BASEMENT ROCKS

The fine-grained rocks (rhyolite, rhyolite porphyry, and granophyre) in Pike and Fayette Counties may represent a belt of flows and related near-surface intrusives. The granites in the two Lee County wells, McElroy and Vedovell, are similar both in composition and in physical appearance, and both probably represent the same body of rock (table 2; entries 9, 10). The remainder, however, show both similarities to and differences from one another, and on the basis of petrography alone no genetic relationships can be established. For example, the geographic restriction of the granodiorites to the northern part of the state suggests that these rocks may be part of a single granodiorite body. However, the fact that the Miller and Seele granodiorites carry the same alkali feldspars as the granites overlying them suggest that these two granodiorites are more closely related to the overlying granites than to the other granodiorites (table 2; entries 5 and 13, 7 and 14). The Will County alkali granite represents a rock type not heretofore encountered in the Precambrian of Illinois or adjacent states, and its significance is difficult to assess.

On a regional scale, the Illinois basement rocks are similar to those found in neighboring states (Bass, 1960; Hayes, 1961a, b; Kottlowski and Patton, 1953; McCormick, 1961) and apparently are part of a large area in which the Precambrian basement is characterized chiefly by plutonic and volcanic rocks of granitic or closely related composition. Andesitic and basaltic rocks are exposed in Missouri (Hayes, 1961a) as relatively minor intrusives into the granites and rhyolites. Similar rocks have been encountered in borings in Indiana (Greenberg and Vitaliano, 1962) where they have been interpreted as flows younger than the granites and possibly related to the Keweenawan lavas of upper Michigan. Also, metasediments have been identified in drill samples from the basement rocks in Missouri (Hayes, 1961b) and Indiana (Kottlowski and Patton, 1953), although Bass (1960) thought that the Indiana samples may be aphanitic volcanics and tuffs rather than metasediments. No Precambrian mafic igneous rocks or metasediments have been encountered in Illinois, and their areal extent and quantitative importance in the central Midwest are difficult to assess.

AGES OF BASEMENT ROCKS

A compilation of data on ages of basement rocks in the Midwest (A. J. Rudman, personal communication, 1964) shows that these rocks are 1.2 to 1.5 billion years old in Missouri, Iowa, southern Minnesota, most of Wisconsin, and much of Indiana. In central and northern Minnesota, northern Wisconsin, and upper Michigan the Precambrian is represented by rocks with ages greater than 1.6 billion years (except for a belt of Keweenawan flows 0.8 to 1.1 billion years old). To the east, in most of Ohio and in southeastern Indiana, the basement rocks are 0.8 to 1.1 billion years old. These younger Ohio and Indiana rocks are assigned by Rudman to the Grenville Province and are believed to be characterized by metamorphic rocks with an age of approximately 1 billion years (Bass, 1960; Tilton et al., 1960).

M. N. Bass (personal communication, 1963) determined an age of 1.26 billion years for biotite from the Otto No. 1 Swenson well in LaSalle County, Illinois (table 1, well 9) and an age of 0.63 billion years for biotite from the Carr No. 1 Vedovell well in Lee County, Illinois (table 1, well 6). The former determination is consistent with ages found in adjacent states. The latter determination, however, is anomalously low and should be considered tentative until corroborated by other data.

TABLE 1 - WELLS IN ILLINOIS THAT

Map no.	Name of well	Location	Completion date	Total depth	Surface elevation	Depth to basement	Elevation of basement
1.	Amboy Oil and Gas Company, McElroy No 1	Approx. SW SW SW 30-20N-10E, Lee Co.	About 1929	3772	714 Company	3760	-3046
2.	Northern Illinois Oil & Gas Company, Taylor No. 1	2200'S line, 1600'E line 28-43N-3E, Boone Co.	Nov., 1931	2998	817 E.T.M.	2921	-2104
3.	Paul Schulte Wyman No. 1	200'N line, 200'E line, SE 35-41N-5E, DeKalb Co.	Aug., 1937	4484	892 E.T.M.	3845	-2953
4.	Herndon Drilling Campbell No. 1	330'N line, 330'E line, NW NW 15-4S-5W, Pike Co.	April, 1944	3207	716 D.F.	3204	-2488
5.	Panhandle-Eastern Mumford No. 1-21	330'N line, 330'E line, NW 21-5S-4W, Pike Co.	Feb., 1948	2226	812 D.F.	2221	-1409
6.	H. O. Carr Vedovell No. 1	330'S line, 328'W line, NE NE 35-20N-10E, Lee Co.	Sept., 1949	3653	812 E.T.M	3465	-2653
7.	Mississippi River Fuel Corporation Theobald No. A-15	185'S line, 419'W line, SE SW 35-1S-10W, Monroe Co.	March, 1952	2768	666 D.F.	2759	-2093
8.	R W. Lawinger Anna Miller No. 1	175'S line, 360'W line, NW SE NE 1-36N-4E, LaSalle Co.	Aug., 1957	3659	681 E.T.M.	3469	-2788
9.	A. C. Otto Swenson No. 1	530'S line, 445'W line, NE 1-36N-5E, LaSalle Co.	Dec., 1957	3725	659 E.T.M.	3700	-3037
10.	Vickery Drilling Company, Mathesius No. 1	330'S line, 330'E line, SW SE 32-35N-1E, LaSalle Co.	April, 1958	3556	677 Company	3515	-2838
11.	Harold L. Kelley Fullerton No. 1	402'N line, 414'E line, NW SE 19-13N-4W, Mercer Co.	April, 1958	3716	580 E.T.M.	3255	-2675
12.	Maryland Service Company, Kircheis No. S-1	672'N line, 660'E line, SW SE 27-3N-6W, Madison Co.	May, 1959	5018	504.6 K.B.	5011	-4506
13.	Humble Weaber-Horn Unit No. 1	619'S line, 330'E line, NW NW 28-8N-3E, Fayette Co.	Sept., 1960	8616	538 K.B	8214	-7676
14.	Ivan Seele Seele No. 1	990'N line, 330'W line 24-44N-2E, Winnebago Co.	May, 1962	3385	870 E T M	2656	-1786
15.	Ralph E. Davis E. A. South No. 2	400'S line, 44'W line, SW cor. 30-16N-1E, Henry Co.	Oct., 1961	3863	793 G.L.	3855	-3062
16.	Reed McCoy No. 1	990'N line, 330'W line, NE NW 20-35N-9E, Will Co	Nov., 1963	4315	631 K.B.	4222	-3591
I-1.	DuPont No. 5	22-81N-6E SE SW NE, Clinton Co.	April, 1947	3216	582 E.T.M.	3205	-2623
I-2.	Dubuque City No. 8	CSL SE SE, 7-89N-3E, Dubuque Co.	1946	1782	610	1765	-1155
I-3.	Dubuque Packing Company No. 5	E½ NE SE, 24-89N-2E, Dubuque Co.		1965	610 E.T.M.	1955	-1345

Abbreviations E.T.M. Estimate from topographic map. G.L. Ground level. D.F. Derrick floor.

ENTER PRECAMBRIAN BASEMENT ROCKS

Basement rock type	Formation resting on basement	Sample set no.	Depth of samples	Core no.	Depth available	Geophysical logs
Red granite	Mt. Simon	348	480-3772			
Granodiorite	Mt. Simon	1100	3-2998			
Red granite	Mt. Simon	1301	75-4100			
Red-brown rhyolite porphyry	Mt. Simon	10940	50-3205	1416	3206-7	Resistivity, potential, drilling time
Red granophyre	Eau Claire	17625	0-2226			
Red granite and felsite	Mt. Simon	17942	150-3653			
Red granite	Eau Claire	22156	1550-1840	2800	770-2761	Resistivity, potential, gamma ray, neutron, drilling time
Granite (3469-3624) and grandodiorite (3624-3659)	Mt. Simon	30734	160-3655	Company core study	930-1144 3342-67	Resistivity, potential, drilling time
Red granite	Mt. Simon	25654 and 30928	120-1360 1360-3695			Gamma ray, neutron
Red granite	Mt. Simon	30917	0-3550	Company study	736-1329	Resistivity, potential, microlaterolog, caliper, gamma ray, neutron, microlog, geolograph (drilling time)
Gray granite	Mt. Simon	30473 and 31725	155-3410 3411-3705	C 3534	3235-40 3681-3706	Resistivity, potential, drilling time
Red granite	Mt. Simon	34200	100-5015	C 3750	2437-2906 5014-18	Resistivity, potential, temperature, microlog, caliper, sonic, gamma ray, neutron, microlaterolog, drilling time
Rhyolite, upper part altered	Mt. Simon	36377	270-8613			Resistivity, potential, laterolog, microlaterolog, caliper, drilling time
Pink granite (2656-3090) and granodiorite (3090-4150)	Mt. Simon	20109	0-2823			
Granodiorite	Mt. Simon	41427	0-3860	C 4213	664-1587; 1725-1769; selected samples of granite	Gamma ray, laterolog, sonic, drilling time
Red granite	Mt. Simon	45073	0-4300			Resistivity, potential, microlog, caliper, gamma and density
Red granite	Mt. Simon	33144	1730-3215			
Biotite granite	Red clastics(?) (Mt. Simon)	Info. from Anderson (1950)				
Biotite granite	Red clastics(?) (Mt. Simon)	Info. from Yoho (1961), Iowa Geological Survey unpublished manuscript.				

K.B. Kelly bushing.

TABLE 2 - MODES OF BASEMENT ROCKS

I. Wells in Illinois (Minerals in percent)

	Name of well	County	Type of data	Quartz	Potash feldspar*	Soda-lime feldspar**	Biotite	Amphibole†	Muscovite	Chlorite	Accessories‡
						Granites					
1	Kircheis S-1	Madison	(1)	35	(P) 62	(An_{10}) 1	1				1
2	Fullerton 1	Mercer	(1)	30	(MP) 37	(An_{10}) 26	tr			4	1
3	Theobald A-15	Monroe	(1)	29	(P) 63	(An_{10}) 4				1	3
4	Mathesius 1	LaSalle	(2)	A	(MP) A	(An_{10}) X	X			X	X
5	Miller 1	LaSalle	(2)	A	(O) A	(An_{10}) X	5+	tr		tr	X
6	Swenson 1	LaSalle	(2)	A	(MP) A	(Olig.) tr	X			X	X
7	Seele 1	Winnebago	(2)	A	(M,P) A	(Olig.) X	X	tr		tr	X
8	Wyman 1	DeKalb	(3)	A	(M) A	(Olig.) X	X				X
9	McElroy 1	Lee	(2)	A	(M) A	(Olig.) 5+	5+	tr		tr	X
10	Vedovell	Lee	(2)	A	(M) A	(Olig.) 5+	X	tr		tr	X
11	McCoy 1	Will	(2)	A	(MP) A			5+		X	X
						Granodiorites					
12	South 1	Henry	(1)	26	(MP) 30	(An_{30}) 34	6	1			X
13	Taylor 1	Boone	(4)	A	(M) A	(An_{30}) A°	X	X			X
14	Miller 1	LaSalle	(2)	A	(O) A	(An_{35}) A°	5+	5+			X
15	Seele 1	Winnebago	(2)	A	(M,P) A	A°	X	X			X
						Rhyolites					
16	Campbell 1	Pike	(1)	35	62		2		X		X
17	Weaber-Horn 1	Fayette	(4)	A	(O) A	tr				X	X
						Granophyre					
18	Mumford 1-21	Pike	(3)	A	(P) A					X	X
						II Wells in Iowa along Mississippi River (Minerals in percent)					
						Granites					
19	DuPont No. 5	Clinton	(2)	A	(MP) A	(An_{10}) X	X				X
20	Dubuque City No. 8	Dubuque	(5)	40	(M,O) 27	(An_{15}) 26	7				X
21	Dubuque Packing Company No. 5	Dubuque	(6) Perthitic potash biotite granite								

(1) Point count on thin section from core
(2) Visual estimate from binocular examination of drill cuttings and petrographic examination of crushed cuttings in oil immersions
(3) Visual estimate from thin section of drill cuttings
(4) Visual estimate from binocular examination of drill cuttings and petrographic examination by oil immersion and thin sections of cuttings
(5) Data from Anderson, K. E., 1950, Basement complex biotite granite at Dubuque, Iowa: Proc. Iowa Acad. Sci., v. 57, p. 241-244.
(6) Data from Yoho, Herbert, Iowa Geological Survey unpublished manuscript.

* Letters in parentheses refer to kind of potash feldspar in rock, O orthoclase, M microcline, P perthite, MP microcline perthite.
** Data refer to kind of soda-lime feldspar in rock by percent of anorthite molecule; olig. refers to acid oligoclase (less than 20 percent anorthite).
† Amphibole is hornblende in all but no. 11 where it is riebeckite.
‡ Accessories include apatite, fluorite, epidote, sphene, zircon, and opaques such as magnetite and pyrite
° Indicates that soda-lime feldspar is more abundant than potash feldspar
A Abundant (generally 20 percent or greater)
X Present in minor amounts (generally under 5 percent)
tr Trace (one to a few grains)

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